

VARIABILITY IN SPORANGIAL TYPES IN *Gelidium canariense* (GELIDIACEAE, RHODOPHYCOTA)

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ABSTRACT

As part of a large study on life history, reproduction and culture of red algae *Gelidium canariense* (Grunow) Seoane-Camba ex Haroun, Gil-Rodríguez, Díaz de Castro et Prud'homme van Reine (Gelidiales, Rhodophycota), the morphology of the sporangia and spores was studied.

The presence of several different types of spores is described, and the importance of this variation is discussed.

Key words: Red algae, *Gelidium canariense*, spores, sporangia, culture.

RESUMEN

Con la finalidad de conocer la morfología de los esporocistes y esporas del alga roja *Gelidium canariense* (Grunow) Seoane-Camba ex Haroun, Gil-Rodríguez, Díaz de Castro et Prud'homme van Reine (Gelidiales, Rodophycota), se han realizado estudios de material cultivado en laboratorio.

En el presente trabajo se describen los diferentes tipos de esporas y esporocistes encontrados y se discute la importancia de su variación.

Palabras clave: Algas rojas, *Gelidium canariense*, esporas, esporocistes, cultivo.

1. INTRODUCTION

The steep northern coast of the island of Tenerife is very exposed, constituting this one of the most decisive factors on the specific composition of the intertidal vegetation which is formed, characteristically, by species that tolerate exposure to big swell. In these intertidal and shallow subtidal environments three species of Gelidiales form successive belts.

The movements of ascent and descent of the tides cause that a section of the coast is submerged and emerged alternatively and this phenomenon determines the specificity of the algal distribution on the basis of the greater or smaller resistance of each species to desiccation (GIL-RODRÍGUEZ & WILDPRET [8]). The zonation pattern of Gelidiaceae algae in exposed areas of Tenerife shows an upper belt of *Pterocliadiella capillacea* (S.G. Gmelin)

Santelices et Hommersand, around 0.7-0.8 m above LAT, followed by a narrow belt of *Gelidium arbuscula* Bory de Saint-Vincent ex Boergesen, down to 0.3 m above LAT, and *G. canariense* (Grunow) Seoane-Camba ex Haroun, Gil-Rodríguez, Diaz de Castro et Prud'homme van Reine occupying the lowest intertidal levels and the upper subtidal (GIL-RODRÍGUEZ *et al.*, [9]; HAROUN *et al.*, [13]). The three species are present just in the lower intertidal where they are under the influence of spray even during low tides (MERCADO *et al.*, [16]). Under extremely intense wave action this zonation is substituted by populations of costrose species (PINEDO & AFONSO-CARRILLO [18]).

Gelidium canariense has not been always considered endemic of the Canaries (AFONSO-CARRILLO & SANSÓN [1]; GIL-RODRÍGUEZ *et al.* [10]). Initially it was described as the variety *G. cartilagineum* var. *canariensis* Grunow (PICCONE [17]). Later SEOANE-CAMBA [21] considered that it presented enough characters to elevate it to specific category and proposed the name *G. canariensis* (Grunow) Seoane-Camba. The name *G. canariense* was proposed in HAROUN *et al.* [14].

PRUD'HOMME VAN REINE & VAN DEN HOEK [19] included the archipelago of Azores in the distribution of *G. canariense*, nevertheless the Dra. A.I. Neto, of the University of Azores, confirmed the absence of the canarian species (*pers. comm.*), stating that the record could be due to a misidentification of *G. sesquipedale* (Clemente) Thuret (DOMÍNGUEZ-ÁLVAREZ *et al.* [6]).

A genetic study of *G. canariense* showed a gametophyte to sporophyte ratio of 1:5 (SOSA & GARCÍA-REINA [22]). DARIAS-RODRÍGUEZ & AFONSO-CARRILLO [5] gave an account on the phenology and reproductive morphology, showing that the species had bispores, and a male: female: sporophyte ratio (in the field) of 1:1:3.

As part of a large study on life history, reproduction and culture of *Gelidium canariense*, in this work the morphology of the sporangia and spores was studied. The presence of several different types of spores is described, and the importance of this variation is discussed.

2. MATERIAL AND METHODS

Field-collected, formalin-preserved (4% in seawater) and Herbarium (TFC) fertile plants (fig.1) were used in this study. Tetrasporangial branchlets were selected and fixed in 1:1 acetic acid: ethanol for 3 h. Sections were made using a razor blade and the fixative allowed to evaporate. Sections were stained with Wittmann's aceto-iron-haematoxylin chloral hydrate. A gentle squashing was applied to cover-slips to separate the spores from vegetative cells. Permanent slides were mounted in 60% Karo corn syrup.

3. RESULTS AND DISCUSSION

Various types spore division were evident in some preparations (fig.2), including bisporangia, irregularly zonated, cruciately and decussately divided tetrasporangia. Bisporangia were by far the most abundant group among sporangia showing any cleavage (Table 1), although the fraction of spores showing cleavage was low (14%). Bisporangia were identified by showing a tranverse division across the shorter axis, and were deeply stained with Wittmann's stain (figs 3,4). The number of nuclei per spore allows to separate bispores (two nuclei per spore) from tetraspores (one nucleus per spore), but in the present case, we have separated bispores only on the basis of morphology. Bispores showed a com-

plete median cleavage (figs 3,4) without any indication of any other cleavages, while in developing tetraspores at least two cleavage lines were always evident (fig.5). Bispores have been described in two other species of Gelidiales: *Suhria vitata* (Linnaeus) J. Agardh and *Gelidium pristoides* (Turner) Kützinger (FAN [7]). In both cases, only bispores were present, and in *G. pristoides* mono-, bi- and tetranucleate bispores were described (CARTER [4]). We have found only binucleate bispores in *G. canariense*, and the presence of two nuclei per spore allows to separate them from undeveloped tetraspores (BOILLOT [3]). Bispores can be found either alone or together with cruciately or zonately divided tetrasporangia (GUIRY [12]). Binucleate bispores are generally assumed to have originated by meiosis (SUNESON [23]) as opposed to uniculate spores, which are mitotically produced. This indirect evidence of meiosis is corroborated by the presence of a gametophytic generation in both *G. pristoides* and *G. canariense*. Direct evidence of meiosis in *Gelidium* species has also been demonstrated (MAGGS & RICO [15]), and it occurs in the immature sporangium.

SPORE TYPE	%
TETRASPORANGIA	
Cruciate	13.1
Decusate	14.7
Irregularly zonate	9.8
BISPORANGIA	59.0
UNIDENTIFIED	3.3

Table 1. Percentage of sporangial types in *Gelidium canariense* (of those showing cleavage. Undivided sporangia not included). Numbers represent the percentage of each type after counting 500 sporangia in 5 different preparations from 5 different plants.

Cruciately and decussately divided tetrasporangia were also present in 25% of sporangia showing cleavage. Strictly cruciately divided tetrasporangia showed two perpendicular cleavage planes (fig.6), while decussately divided tetrasporangia showed 1-3 cleavage planes depending of the position of the squashed preparation (fig.5). Although in some cases cruciately divided tetrasporangia can be erroneously identified as bispores (GUIRY [11], [12]), this is not the case with *G. canariense*. Basically, bisporangia and decussately cruciate tetrasporangia can be distinguished by counting the number of nuclei per spore, but also, as previously indicated, by the number of cleavages observed.

Irregularly-divided zonate tetrasporangia were rare, although present in most samples of *G. canariense*. Up to 2 parallel cleavage lines were identified in the 'equatorial' plane (figs 7,8). The remaining cleavage varied in its orientation and were always in a plane distinct from the short axis (fig.7). Zonately divided tetrasporangia are unknown in the order Gelidiales, and are considered to have independently evolved in the Order Cryptonemiales (now in the Gigartinales), Gigartinales and Corallinaceae (GUIRY [11],[12]). Zonately divides tetrasporangia are considered to have derived from cruciately divided tetrasporangia (GUIRY [12]) because, as the case shown with *Gelidium canariense*, intermediate types, or the simultaneous occurrence of them, is frequent. It can be concluded that this variation in spores types

could be derived from variation in the presence/absence of the second cleavage, and by its orientations with respect to the first one (fig.9). It should be pointed out that irregularly zonate divided tetraspores bear no relationship with regularly zonate divided tetraspores, as has been pointed out before (GUIRY [12]). In the case of regularly zonate tetrasporangia, all cleavage planes develop simultaneously, while in irregularly zonate tetrasporangia may show intermediate stages in cleavage formation and development (figs 7-9).

Accordingly, *G. canariense* may represent an intermediate state in the selection of a type of spore production, which has been explained in terms of ecological advantages of the progeny in some other cases (CARTER [4]). However, the relative importance of the sexual reproduction seems to be low, as shown by the gametophyte: sporophyte ratio (DARIAS RODRÍGUEZ & AFONSO-CARRILLO [5]; SOSA & GARCÍA-REINA [22]) and the importance of vegetative growth in species of *Gelidium* (AKATSUKA [2]; SANTELICES [20]).

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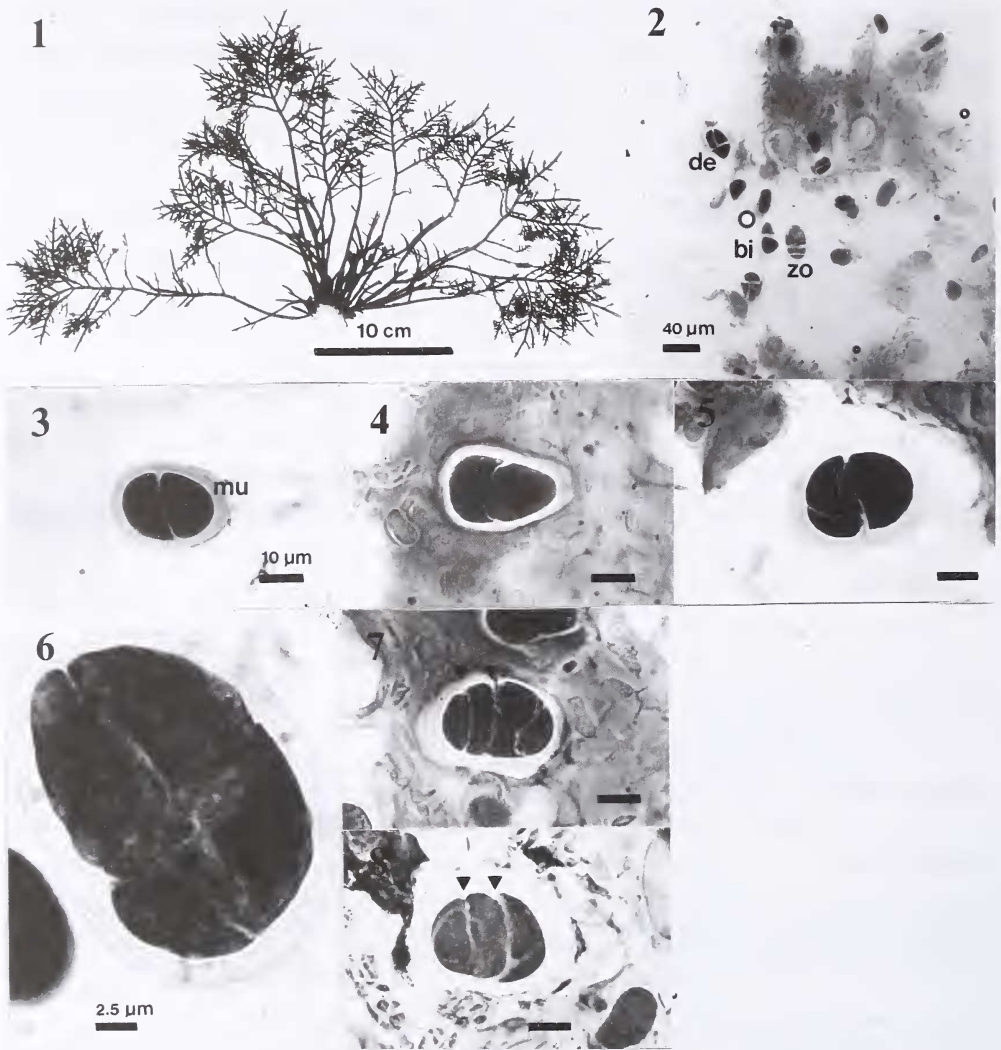


Figure 1. Habit of *Gelidium canariense*. Herbarium specimen.

Figure 2. Squash preparation of tetrasporangial branchlet showing bisporangium (bi), decussately divided tetrasporangium (de) and irregularly zonate divided tetrasporangium (zo).

Figure 3. Bisporangium. Note the enveloping mucilage (mu).

Figure 4. Bisporangium. Same scale as in fig. 3.

Figure 5. Decussately divided tetrasporangium showing two cleavage planes. Same scale as in fig. 3.

Figure 6. Cruciate divided tetrasporangium.

Figure 7. Irregularly zonate divided tetrasporangium. Two equatorial cleavage planes are evident (arrowheads). Same scale as in fig. 3.

Figure 8. Irregularly zonate divided tetrasporangium. Two equatorial cleavage planes are evident (arrowheads). Same scale as in fig. 3.

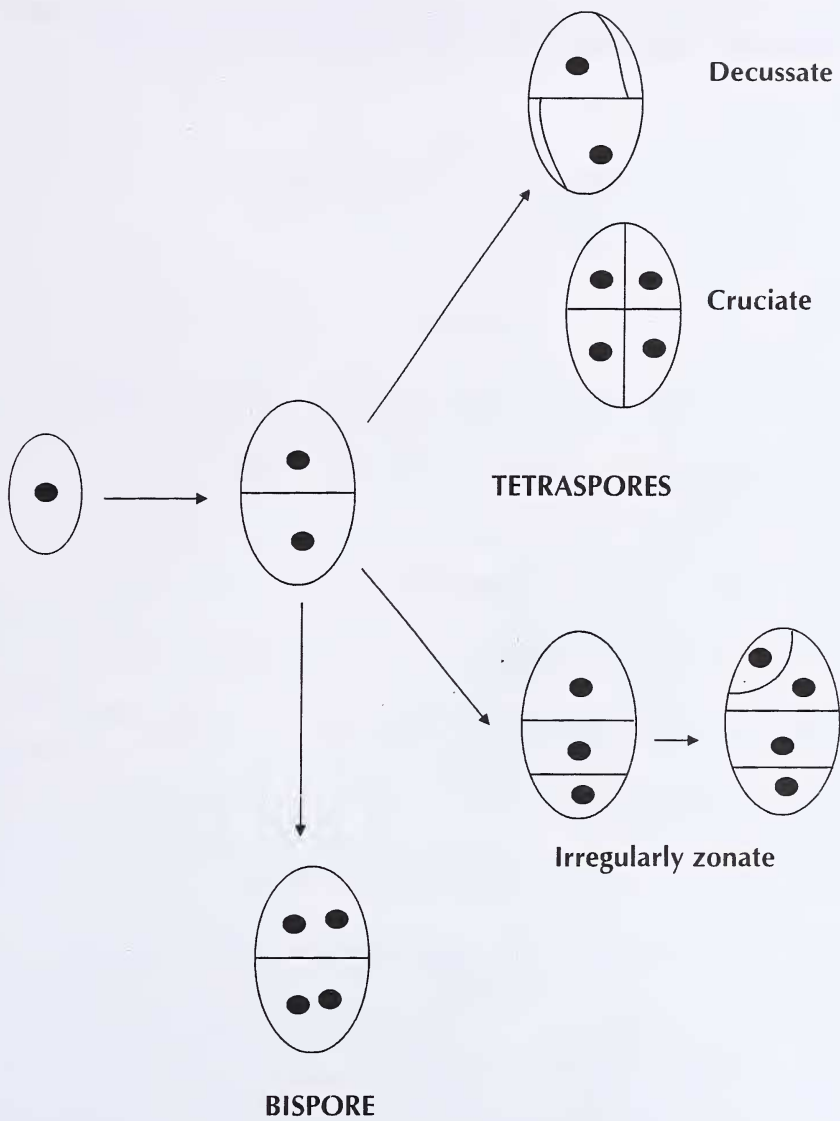


Figure 9. Schematic representation of the possible origin of different spore types in *Gelidium canariense*.

